

NOTES ON INDIAN BATRACHIANS.

BY

C. McCANN, F.L.S.,

Assistant Curator, Bombay Natural History Society.

(With 10 plates and 2 text-figures).

INTRODUCTION.

The observations in this paper originated in a discussion over the length of the period of development of tadpoles of the common Indian Bull-Frog (*Rana tigrina*), which led me to solve the problem by actual experiment.

Once I took up the subject, it became so fascinating that I carried my observations further than I had originally intended, and was stimulated to do so by the paucity of the information on the life-histories of Indian frogs. As a boy I had frequently attempted to rear tadpoles, but failure, due to insufficient knowledge of the subject, was invariably the result. About six years ago, when the discussion, referred to above, took place, I tackled the subject once more and only after repeated failures, I eventually succeeded. I am fully conscious of the incompleteness of the observations here recorded, but I submit them in the hope that this short paper will stimulate others to follow up this very fascinating subject.

Much has been written on the different species of Indian Batrachia, both from the viewpoint of the Systematist and the Anatomist, but, as is generally the case, comparatively little appears to have been done from the angle of the Field Naturalist. A glance at the *Fauna of British India* Reptiles, by Boulenger, soon shows us how little was known about the different species beyond their systematic position. The *Records of the Indian Museum* contain a considerable amount of information. Dr. G. A. Boulenger, the late Dr. N. Annandale, and Mr. Narayan Rao, have all contributed much towards the study of Indian Batrachians. Nevertheless, in spite of their efforts, there still remain innumerable gaps to be filled in, particularly in connection with the life-histories and habits of the various Indian species, which naturally involves a study of the tadpole stages. It is frequently too difficult to rear tadpoles to the 'frog stage', on account of their delicacy, and very often, even when they have developed thus far they are very difficult to identify. In this paper it is my intention to place on record such information, as I have been able to accumulate over a period of six years of continuous work during the monsoons, and after.

As a preliminary to my observations, I submit a few remarks on the methods I adopted and a few notes on the rearing of tadpoles.

COLLECTING AND REARING TADPOLES.

Collecting.—The best time to collect is at the break of the monsoon, just after sufficient rain has fallen to bring the frogs out of their hot weather retreats (of course, this will depend much on the locality).

At such times I used to set out, armed with numerous old tins and bottles, and carefully collect the fresh spawn or larvæ (these frequently develop in a few hours) and as carefully convey them home. On no account close or stopper the receptacle containing the larvæ or the tadpoles or they will surely die from suffocation. I found it necessary also to change the water in the containers as frequently as possible, to prevent the captives dying *en route* for want of oxygen. Fresh eggs do not matter so much as there is usually sufficient time to get them home safely. On arrival home, the eggs and larvæ were gently transferred to larger containers. My 'aquaria' consisted of empty tins, basins, in short, anything that would serve the purpose. Owing to a small and usually empty purse, I had to content myself with such 'aquaria'. A disused bulb enema served me both for emptying the 'tanks' and for aërating the water. This I usually did two or three times a day. Aquatic plants were also used for the same purpose, but owing to the 'aquaria' being usually of metal they did not do too well owing to the absence of sufficient light.

Each container was properly labelled with the name or the number of the adult frog preserved in spirit, the date when the spawn was obtained, and the locality. As development proceeded one or more specimens were preserved at intervals of one, two, or more days (in some cases at intervals of hours), this being governed by the number of specimens I had. The tadpoles were examined both alive and dead under a dissecting microscope. An eye was kept on all living specimens both during the day and during the night. Unfortunately, owing to my official duties, I was unable to give them sufficient time during the hours of daylight, except on Sundays and holidays.

Adult frogs were also kept under observation in cages constructed of old boxes covered over with wire mesh, and were also studied in the field.

It must be indicated clearly that my observations are based entirely on data derived from specimens which have been carefully reared. No specimens of spawn have been considered for the purposes of this paper, unless the adults were obtained with the spawn (unless otherwise stated). It is very important that one should be quite sure of the species to which the spawn or tadpoles belong. Random collecting of tadpoles and frogs found in the neighbourhood was therefore avoided, as the writer was fully aware of the difficulties besetting the identification of immature frogs and tadpoles.

To collect spawn or tadpoles at random and to assign them to the different species because of their presence in the locality leaves much room for error and is a method to be condemned. Tadpoles caught in the field should be reared until the 'frog stage'

is reached and then kept some time longer before being preserved for identification. This gives time for the teeth to be formed which is an aid in the determination of the species. Even so, the identification of immature frogs is a very difficult proposition.

The rearing of tadpoles.—The rearing of tadpoles has frequently presented a knotty problem to those desiring to study them. Though they can survive a considerable time without food, they cannot do so indefinitely. When food is scarce, cannibalism is resorted to and the stronger prey on their weaker brethren. I tried all possible methods of feeding them before I was able to hit on something that was really satisfactory. However, my suggestions are not the last word on the subject and I am sure there is still much room for improvement.

In the rearing of tadpoles there are three important points that require attention, (a) *the correct food*, (b) *well aerated water* (though in some cases they prefer stagnant water), (c) *that no carnivorous insect larvæ are present in the rearing 'tanks'*. Even the larvæ of mosquitoes are detrimental to the small tadpoles. I have seen a fully developed mosquito larva catch and kill a tadpole two centimetres long; while the tadpoles of only some species of frogs feed readily on mosquito larvæ.

(a) *Food.*—The best food I have found for tadpoles is raw meat. The ideal way of providing it is to suspend a small piece of meat tied to a thread just below the surface of the water (not too deep). Should there be a large number of tadpoles in the same container it is advisable to put in two or three such pieces, in this way all the competitors get a chance, and there is no danger of one tadpole eating another's tail for want of opportunity to get at the meat. In some instances dead insects and live snails also serve as food. Animal matter alone is not sufficient. This should be supplemented by green vegetable matter, such as algæ and water weeds. This is best done by introducing such water plants as *Hydrilla*, *Ceratophyllum*, *Nias*, the common Duck weed, *Lemna*, or *Valianeria*, known as the Tape- or Eel-grass. But in doing so it is very important to guard against the presence of the larvæ of carnivorous insects.

(b) *Water.*—Under no circumstances should the water be allowed to become too foul. This is most detrimental to tadpoles. Oxygen is very essential. Water plants are of the greatest use here, provided the aquaria are in well lighted positions otherwise the action of the plants is reversed. They will deprive the water of oxygen. A good way of aerating aquaria without having to purchase expensive apparatus is to use a bulb enema or something similar—it suits the purpose well. It is advisable to aerate small aquaria at least twice a day. A sure sign that the aquaria need aerating is when the tadpoles all rise to the surface and remain there. The water in small aquaria should be changed at least once in two days. In the alternative, part of the water should be drained off and replaced with a fresh amount. When changing water it is best to strain it through a cloth to prevent the tadpoles from escaping. A syphon is not advisable as the tadpoles pass through the tube or get stuck in the mouth. Straining them through



The Water Skipper (*Rana cyanophlictis*, Schneid.) in slush, its most common habitat.

Photo by C. McCann.

a cloth in no way injures the tadpoles, provided that they are not kept too long out of water. After straining them through a cloth they should be put into a small receptacle till the containers have been washed and then carefully returned to the aquaria. Care should also be exercised when pouring fresh water into the aquaria—the flow should be very gentle as the tadpoles are likely to be damaged.

(c) *Carnivorous insect larvæ*.—This point needs special attention. Great care should be taken when introducing water plants into the aquaria to see that no aquatic insect larvæ are put in along with them. Dragonfly larvæ are particularly to be guarded against as they are especially dangerous to the tadpole life in the aquaria. Many such larvæ are coloured like the weeds and are easily overlooked. On one occasion I lost the greater part of a fine set of tadpoles owing to the presence of a dragonfly larva which I could not detect, until it was almost too late.

Another point that may be mentioned here is that all the tadpoles of one batch do not develop at the same rate and it very often happens that the larger ones prey on the smaller. In such cases it is advisable to separate them.

With regard to the general habits of frogs I have found it extremely difficult to decide whether certain species are diurnal or nocturnal. During the dry season most of them certainly appear to be nocturnal, however, this is easily explained by the fact that frogs possess a humid skin, cannot stand long exposure in the hot sunlight, but during the rains and in wet localities I have found them about both day and night. For example *Rana cyanophlictis* is both diurnal and nocturnal when it lives in tanks and swamps and it also undertakes long journeys by night during the dry season. *Rana tigrina* appears to be nocturnal during the dry season while during the rains it is both diurnal and nocturnal—but even during the early monsoon it retires should there be long hours of sunshine. *Rana breviceps* on the other hand is truly nocturnal both during the rains and during the dry season. I only quote these instances to show how difficult it is to decide this point.

In conclusion I wish to express my thanks to Dr. Malcolm Smith of the British Museum for very kindly identifying most of my material, to Mr. Salim A. Ali for some of the photographs he has taken for me and to Mr. C. C. A. Munro of the British Museum for the identification of the leeches referred to in connection with this paper.

RANA CYANOPHLECTIS Schneider.

The Water Skipper.

The English name indicates a characteristic habit of the frog which can move over the surface of the water in a series of short leaps.

This species is perhaps our commonest frog; met with at all seasons of the year, wherever there is sufficient water. It is

almost purely aquatic and both diurnal and nocturnal. It is the commonest frog too, in tanks, pools, and streams, whether temporary or perennial, clear or stagnant. I have also found them in cisterns in which the water was soapy. In Thana I have seen them in abundance in open gutters where the water was very foul and full of kitchen refuse, often discoloured with saffron and currysuffs, but the frogs did not seem to mind it. When hot water exuded from the drains the frogs just moved away and returned when the water cooled—adaptation to environment! One sees it frequently on the banks of streams but it certainly has a predilection for still water where it can leisurely float on the surface. This character, coupled with its peculiar habit of *skipping* over the surface of the water when alarmed, readily distinguishes it from any other species. I know of no other frog that is capable of performing this feat, though it has been attributed to *R. limnocharis* and *R. hexadactyla*. Annandale¹ has rightly pointed out that *R. limnocharis* is quite incapable of performing this feat and that *R. hexadactyla* does so but quite feebly on account of its large size. *R. cyanophlictis* appears to have a liking for sunshine, for it may be seen even during the hottest part of the day, floating on the surface of water.

If alarmed, when sitting on the bank, it will leap into the water and 'skip' along the surface for some distance and then float; but if this precaution is insufficient to avoid the danger it just 'skips' along a little further. If already in the water it will either 'skip' away or, if still threatened, nose dive to the bottom into the mud. There it partially buries itself leaving only its two eyes above the mud, in a position to keep an eye on the actions of the intruder. Although aquatic, the frog cannot remain under water for very long. After a few minutes it cautiously reappears on the surface. Its two eyes and the tip of its snout first show themselves above the water, much after the fashion of a crocodile; the rest of the body dangles under the surface. If not disturbed, it will rise once more to float on the surface.

The Skipper Frog is an extremely active creature and is as much at home on land as in the water. During the day it rarely strays far from water, except during the monsoon months when it is found almost anywhere. There appears to be no doubt that this species does undertake long journeys during the night, it would be difficult otherwise to account for its sudden appearance in water holes which have been recently excavated.

During the period of aestivation, I believe that it buries itself deep in the mud of tanks, and there tides over the dry season, but with regard to this point I have no personal experience.

These frogs call, at almost any season, at any time of the day, though they are certainly more vocal during the monsoon, both day and night. The voice resembles a somewhat low pitched rattle, much like the unbroken rattle of castanets or 'bones', kept up for a short while. The sound is produced by two bluish-white, obovoid vocal sacks which are first inflated gradually and then

¹ *Rec. Ind. Mus.*, Vol. xv, p. 122 (Bombay Streams Fauna).

slowly, but not completely, deflated. This may be done when the frog is at rest on the bank or when it is floating on the surface of water. Any one familiar with the vocal productions of frogs is easily able to recognise its distinctive call.

This frog is a very voracious feeder, and is able to secure its prey both above and under the surface of the water. Its food consists of insects, little frogs and it is largely responsible for the destruction of a great number of tadpoles and insect larvæ, particularly when these come to the surface to take air. To test this, I kept a specimen in a deep jar and introduced a number of tadpoles into the water. As soon as the frog saw them, without the slightest hesitation, it immediately dived under the surface and swallowed the tadpoles one by one using its forelegs to hasten the meal.

The spawn is laid in pools and tanks at the break of the monsoon, but it is possible that this thoroughly aquatic species may breed at any time of the year in suitable localities.

Though I have not so far come across the spawn, I have repeatedly taken tadpoles of this species and reared them to the frog stage. The tadpoles are very pugnacious and attack one another. The victors feeding on the body of the vanquished. In the earliest stage the eyes are placed on the side of the head but appear to creep to a more dorsal position as the tadpole develops.

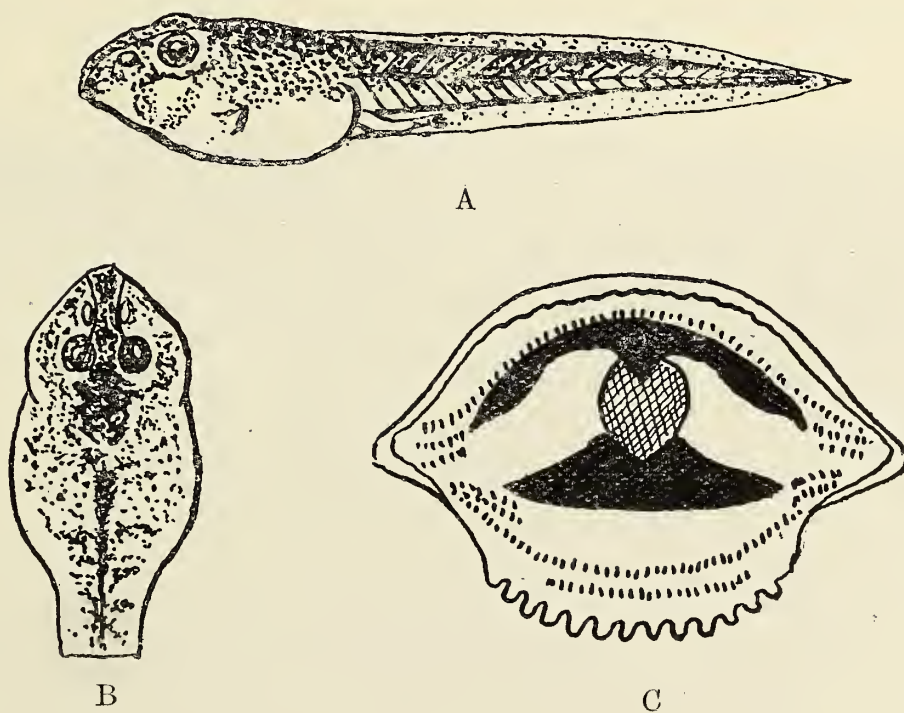


FIG. 1.

Rana cyanophlictis, Schneid. A. Tadpole $\times 2$. B. Dorsal view of figure A. C. Lips and horny teeth. The cross-lined portion indicates the palatine plate.

The largest specimen of a tadpole with the hind legs fully developed measured 44 mm. This specimen was taken in a cistern at Sion, Bombay Island. Annandale and Narayan Rao¹ in a paper

¹ *Rec. Ind. Mus.*, Vol. xv, p. 31.

on the 'Tadpoles of the Families Ranidae and Bufonidae in the Plains of India' give the measurements of two specimens of this species, one from the Chilka Lake and the other from Kashmir. They respectively measured 65 mm. and 71 mm.—one about half and the other more than half again larger than the one measured by me. This seems to show that the tadpoles of this species may vary considerably with the locality, though it must be indicated that my specimen was reared under artificial conditions. A young frog, six hours after leaving water and after completing its metamorphosis measured 17 mm. The tail was almost completely absorbed, leaving only a very small stump which did not protrude beyond the length of the animal.

Young frogs, when they have completed their metamorphosis, leave the water and sit about on rocks and stones for a considerable time, only resorting to it when danger threatens. In this way they sit about for three or four days without feeding, after which they eat greedily.

Judging from comparison, I am inclined to believe that this species takes from three to four years to reach maturity.

The tadpoles of this species devour mosquito larvæ. Mosquitoes were totally unable to breed in the containers in which these tadpoles were kept, whereas they bred freely in some of the other containers.

RANA TIGRINA Daud.

The Indian Bull-Frog.

The Bull-Frog, the largest of the Indian frogs, may be met with at almost any time of the year in wells and tanks. Under these conditions its colouring is sombre brown. Some examples have a pale stripe down the back. Frequently it is mottled with darker and lighter patches of the same colour (brown) and at times there is a suffusion of dull green and yellow here and there. The under parts are generally white with a pinkish tinge on the lower portions of the thighs. Bull-Frogs living in situations where the water dries up bury themselves deep in the earth soon after the rains have ceased and reappear again at the break of the next monsoon. During the period of æstivation a number of them congregate in the same hole. Aestivating frogs have frequently been found twenty and thirty feet below the surface of the earth, particularly when wells are being dug. It is probable that they go deeper in search of moisture. Frequently, disused rat holes are used for the purpose. During the dry season, a frog which has taken shelter in one of these burrows may occasionally be enticed to leave its retreat if sufficient water is poured down it. It will then come up and sit at the entrance of the burrow and take a look round, but conditions not being quite what it was given to expect, it soon pops in to 'sleep' again. This experiment may be repeated and the frog will respond each time—probably it gets swamped out—whatever the causes the result is always the same. Many of the Bull-Frogs which appear from their dry weather



The Indian Bull-Frog (*Rana tigrina*, Daud.) in a pool at the break of the rains.

Photo by C. McCann.



The Indian Bull-Frog (*Rana tigrina*, Daud.)

Photo by S. A. Ali.

retreat are a pale lemon yellow. At the break of the monsoon they are to be heard and seen all over the countryside congregated about tanks and ponds. The lemon yellow raiment is the wedding garb of the males of this species. What is it that brings about this striking change in their colouring? It has often been thought that the yellow colour was due to the darkness or absence of light in their retreats during the long period of aestivation. If this were the case, why is it that only the adult males are so coloured? The females and the young males are the usual sombre brown yet they have lived under the same conditions. Here we have a point which explodes the theory of light action. If the colouring were due to the action of light alone, the females and the young males ought to be of the same yellow colour as the adult males!

I am unable to offer any explanation of this most interesting question. The fact remains that the adult males alone are yellow. Beside this characteristic, the males possess another mark of distinction in the shape of a pair of large vocal sacs, one on either side of the gape (below). These are coloured a vivid cobalt blue. Boulenger and Annandale¹ in a note entitled '*Further Observations on Rana tigrina*' state the following:—'Males with white or grey external vocal sacs on each side of the throat'. This may be so in preserved specimens, but it is certainly not the case in the living frog, the vivid colouring of the vocal sacs persists even for a considerable time after the breeding season. The sacs are inflated and deflated when the Bull-Frog emits its powerful croak. They present a striking contrast to the yellow of the body. With its vocal sacs each frog is capable of producing an enormous volume of sound which can be heard over a long distance. When there are several scores vying with one another the noise is deafening.

When the frogs first emerge with the break of the monsoon, their primary instinct is that of mating. All the males are in search of wives! For the first three or four days, sometimes for a week or a little more, depending much on the weather conditions these stalwarts dressed in their nuptial attire sit about and croak, all alert and on the *qui vive* for the discovery of a female in their midst. The females make their appearance at the same time as the males. They wear no wedding garment but appear in their sombre work-a-day garb, as such, the female is readily recognised. She sits very close, as if frightened out of her wits, by the great concourse of would-be suitors. As long as she sits still she is safe but the slightest move on her part and she is detected. There ensues a frantic scramble among the males in her vicinity—a battle royal for the possession of the female ensues. The fighting is done with the hind legs. Biting is never resorted to and in all my experience I have never known a frog to bite. This is easily accounted for by the fact that opening of the mouth interferes with the respiration. The competitors kick vigorously. The individual who has secured a bride—and this is generally the one who was closest to

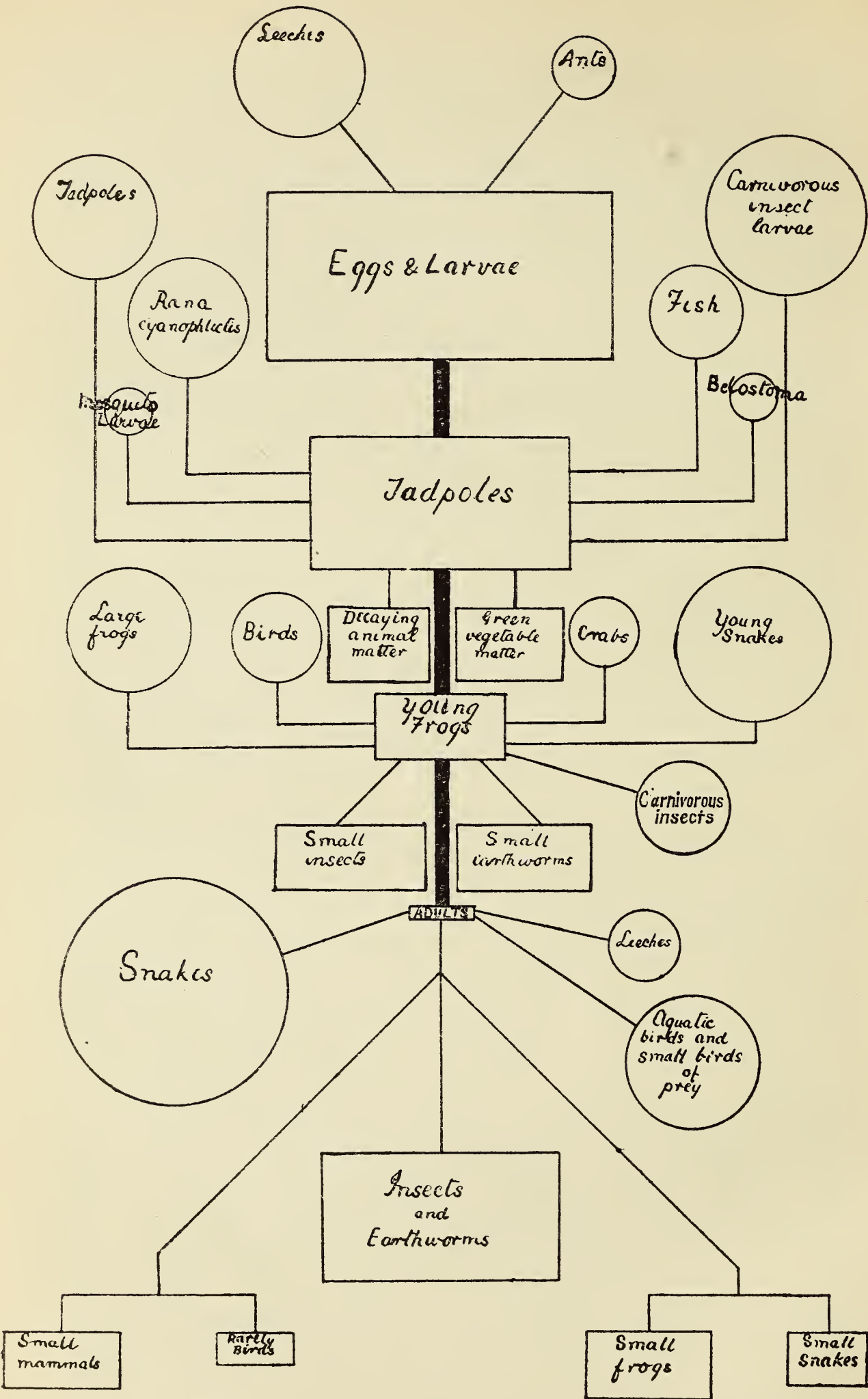
¹ *Rec. Ind. Mus.*, Vol. xv, p. 57.

her when she was discovered—holds her with his fore legs and kicks his opponents aside if possible.

Not infrequently, however, these all too eager males in mistake seize a dull coloured male, but the error is soon discovered. It must be explained here that in the gathering of males, the brightness or the uniformity of the yellow colouring decreases—there are some which are darker in colour which have presumably lost the freshness of the colouring exhibited by them on emergence. These individuals, as I have stated, are occasionally mistaken for females. The conclusion suggested is that the male is guided mainly by colour in distinguishing the female of the species.

As soon as a male secures a mate his croaking ceases till the next year and, after amplexus is over, the male begins to lose his yellow coat. The yellow first becomes suffused with green and in a few days the males have resumed their usual colouration and are as inconspicuous as the females. Another curious point arises here. The males which remained above ground during the dry season, according to my observations, retain their normal colouring. Specimens kept in captivity by me exhibited no change. Do they take part in the sexual excitement displayed at this period, and do they stand the same chance of obtaining mates? There is no doubt that they croak, but I have never observed one of these males in amplexus. If mating takes place in a tank or a large pond the process is not completed there, but the female still in the grasp of the male will scramble out and make for one of the numerous shallow puddles in the vicinity. Here she discharges her eggs, the male fertilizing them at the moment of extrusion.

The eggs are deposited in small puddles and not in large pools as one might expect. This procedure is very often detrimental to a very large number of eggs, as the puddles dry up and the eggs are destroyed, if there is no rain in a few hours or days as the case may be. Apart from the risk of the eggs themselves drying, ants are responsible for destroying large numbers of them so stranded. Yet I believe, that the provision is a safeguard, as there are fewer enemies to destroy the eggs in such puddles. The eggs are laid singly, and each is surrounded by a transparent jelly-like substance. In this they float about for a time drifting about with the wind till at length a number of eggs become agglutinated together and form one mass. After a couple of hours or so they sink *en masse* to the bottom of the pool. An examination of the mass reveals each egg is enveloped in its own jelly-like substance and united to the main mass by a stalk of the same matter. The eggs with their investments have the form of minute spherical electric lamp bulbs. The upper half of the egg is black and the lower half creamy, the black half is always turned towards the sky. Segmentation is very rapid, the larval stage is soon completed and under favourable circumstances, the tadpoles leave the surrounding slime in about four days. As soon as they leave the slime they come to the surface of the water and remain hanging there, tail downwards, for a considerable time, before they swim about freely. During the period they are enveloped in slime, I have found, in



The Food and Enemy cycles of the Bull-Frog (*Rana tigrina*). The rectangles connected by thick black lines show approximately the proportionate development of the frogs. The other rectangles indicate the food at the different stages of development. The circles show the inimical factors.

certain localities, that the leech, *Hirudo birmanica* (Blanchard) is very inimical to both the larvæ and the young tadpoles. This creature is responsible for the destruction of large numbers of them. It sucks out the larvæ and a quantity of its investment of slime. A leech, taken after feeding on the larvæ, contained mostly slime and blood in the alimentary canal.

With the continuation of the rain, the tadpoles are swept into the larger pools. Here they go through their metamorphosis. They are preyed upon by fish, other frogs, particularly, *R. cyanophlictis*, who captures them under water, the young of the Checkered-Water Snake (*Tropidonotus piscator*) which also emerges at this time, and last but not least, a host of insect larvæ, among which the dragon-fly and carnivorous water beetle larvæ, not to mention the water bug (*Belostoma indica*) are the foremost. In addition to numerous external enemies the tadpoles themselves are largely responsible for their own destruction as the larger ones prey on their smaller brethren. Cannibalism is rampant among them and there is always a variation in size and numerous smaller ones to be preyed upon as tadpoles of the same set of eggs do not develop at the same rate. When the metamorphosis is completed and the young frogs are ready to leave the water, they make their way into the grass and remain there for the rest of the season till it is time to aestivate. All immature frogs of the previous years are to be found in the grass and in the fields throughout the rains. At this stage they are much more green in colour than the adults. Judging from comparison it takes a bull frog about 6 to 7 years to mature.

The first instinct of the frogs as soon as they appear with the break of the monsoon, is the propagation of the species. When this has been fulfilled their attention is next turned to feeding. The croaking has stopped—there is no time for entertainment. The yellow frogs have *disappeared*. When they first appear they are thin and emaciated after their long fast of nearly eight months, though, I am of the opinion that their thinness is more due to the absence of water, however, in a couple of weeks they look quite healthy.

The food of the Bull-Frog is varied. Insects constitute its chief diet. Small mammals, rarely small birds, snakes and other frogs, lizards, earthworm; in fact any creature that is easily overpowered is included in the diet. Frogs are the prey of numerous snakes and small snakes sometimes over-estimate their powers and fall victims in a foolhardy attempt to seize one of these giants, several times too large for them, notwithstanding the elasticity of the snake's jaws and its extraordinary capacity of swallowing prey exceeding it in calibre. I have watched one of these combats in which the hunter was 'hoist with its own petard'. As the snake tries to capture the frog, the intended victim hops round and faces its antagonist keeping it in 'full view'. He emits a short croak or two and bides his opportunity to pounce on the snake with an agile leap. It seizes the snake in its mouth gripping it anywhere along its length and with the aid of its fore legs, which it uses alternately like two hands it literally stuffs the struggling reptile into its mouth. The process has of necessity to be very rapid as it

is well known that a frog is unable to breathe properly with its mouth open.

On another occasion I gave a captive frog a small Buff-striped Keel-back (*Tropidonotus stolatus*), a very common snake in our fields during the monsoon. It was immediately pounced upon and swallowed. The snake bit the frog in several places as it was being swallowed, but this the frog only treated with a flick of its hind leg which soon dislodged the jaws of the snake. Any foreign matter on the back of a frog is immediately dislodged with the hind legs while the fore legs are used for anything that might be on the 'face'. When earth is taken along with food it is ejected and wiped away with the fore legs.

In every case food has to be seen moving and it is only then that it is pounced upon. In fact anything that shows the slightest signs of movement is seized, and if not edible is at once rejected. To test this point I tied a small stone on to a thread and threw it to a Bull-Frog, as it fell it was immediately seized and as quickly rejected. If I moved the stone by drawing the thread the frog pounced on it once more and again spat it out. This performance was repeated several times with the same result. Experience did not seem to teach the frog that the stone was not edible. Anything small that moved was prey and the creature instinctively obeyed the impulse to seize it. When in the act of swallowing the large eyes are always depressed.

Besides the powerful croaking referred to above this frog is able to make another sound which is only uttered when in pain, as when the creature is seized by a snake. It is a loud scream, almost human, which is most uncanny if heard and not recognised. When caught the batrachian inflates itself to bursting point, a common feature with most frogs when on the defence, and then gradually deflates, at the same time making a gentle noise which may be expressed by the word 'kut' repeated several times. The process is repeated by maximum inflation, being followed by gradual deflation to the accompaniment of the sounds described.

The enemies of the Bull-Frog are many. Snakes, particularly the Checkered Water-Snake (*T. piscator*) and the Dhaman (*Zamenis mucosus*) feed freely on these frogs. Among the birds, I have repeatedly seen the Shikra (*Astur badius*) capture them from the water—not to mention the host of aquatic birds. Jackals are said to eat frogs but of this I have no direct evidence.

Bull-Frogs have a very great power of endurance and the following experiment which I tried will illustrate this. A few frogs captured after the break of the monsoon were kept perfectly dry. In three days the animals were bone dry, stiff, and hard, with the exception of the abdominal region which was still a little soft. Their shrunken skins revealed every bone. The abdominal region had caved in under the transverse processes of the vertebræ, the bones appearing quite distinct. The tissues of the body had become so hard in this process of drying up, that when dropped on the table my frogs clattered like so many pieces of wood. Respiration and other functions had entirely ceased and the eyes were completely closed—to all appearances my specimens were quite

dead, dead as proverbial door nails. I believed my experiment at an end. However, I left them for another day and on the night of the fourth day I placed them in a tub of water, to see if they would revive. When placed in water they floated on its surface like corks. About twenty minutes later, to my astonishment they began to show signs of returning life. The hind limbs stretched out gradually and sank below the surface of the water, while the rest of the body floated. The valves of the nostrils, which up to this time had been closed, opened by degrees, and the membrane, under the lower jaw, which is constantly in motion during activity due to respiration, began to move again, but slowly, and at intervals. Till immersion it was as dry as the rest of the body. Soon after, the eyes opened gradually, the frogs were able to recognise my presence and made feeble efforts to submerge, they failed only to succeed a few minutes later. They floated listlessly on the surface of the water. But the process of revival continued and an hour after they were put into the tub, they were just able to jump out of it, and after the lapse of four hours the outline of the bones disappeared the fleshy roundness of form was restored and my frogs were quite themselves once more, apparently none the worse for their experience. These frogs I kept for several months before releasing them. The incident strikingly indicates this frog's extraordinary power of endurance, and in some way helps to explain its ability to withstand the rigours of its long period of aestivation.

The Bull-Frog may be kept in captivity for years. It will readily feed on cockroaches, other insects and small mammals and birds, earthworms, lizards and snakes. It will feed on raw meat, small pieces should be suspended from the top of the cage by a thin thread just strong enough to hold the pieces of meat, but not to take the weight of the frog. When the pieces of meat swing about the frogs jump up and take them thread and all.

External parasites.—In the Island of Salsette I have observed a large leech feeding on the larvæ as I have already mentioned above, but this could hardly be considered as a case of parasitism, as the prey was generally completely destroyed. However, I have found the same leech on adult specimens as well.

The most interesting instance of parasitism in connection with the Bull-Frog is that exhibited by a small leech, *Paraclepsis prædatrix* Harding, which, beside attacking the bodies of their host in many cases caused total blindness. The circumstances are worthy of note.

In December 1931, while at Abu Road, Rajputana, I visited a well which I knew to contain many frogs, to catch some of them for study. When I put my net into the well, I noticed that many of the frogs did not pay the slightest attention to it. At first I attributed this to the temperature as it was a very cold morning. Under such conditions frogs do not appear to like to submerge or remain long in the water. However, I dragged some of them up and on removing them from the net to the collecting bag I found that my hand was covered with small green leeches. Even then it did not strike me that the frogs were blind and that the leeches were responsible for their condition. Some of the frogs had their

eyes completely closed. I put my first catch into the bag and it was not till I drew up the second lot that I examined the frogs. On examination, I noticed that the frogs were very badly attacked by the leeches. The leeches had lodged themselves under both the upper and lower eyelids. On my arrival home I re-examined the frogs and to my surprise took 27 leeches out of one eye and 14 out of the other of a single specimen! The other frogs also had large numbers in their eyes, but none of them approached the number of the specimen just referred to. The irritation set up under the eyelids by the presence of the leeches probably compelled the frogs to keep their eyes permanently closed. In each case there was generally a discharge of mucus from the eyes and the frogs would occasionally brush their eyes with the fore legs. On dissection of an eye it transpired that the leeches had not gone any further than the eyelids. The eyeball in each case appeared to be somewhat withered and the lustre of the eye, such a common feature of a frog's eye, was completely lost. The pupil was reduced to a fine black spot, not the usual large pupil met with in these frogs.

The problem that now presented itself to me was, how were these animals able to exist in this blind condition? In order to see if they had had any food, I dissected the stomach and the alimentary canal. In almost all the cases both the stomach and the alimentary canal were empty with the exception of a quantity of mucus. Probably these animals would have eventually died of starvation while the leeches relieved them of the little blood that they possessed.

Below I give the measurements of the tadpoles of this species and also such notes as I made at the time, at different stages of their development.

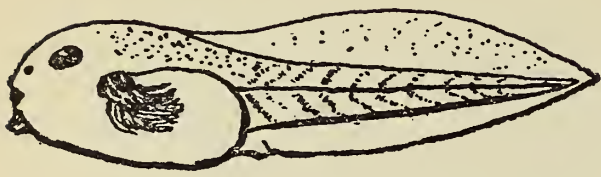
NOTES ON THE DEVELOPMENT OF THE TADPOLES.

On the 9th. of June 1929, I came across a large number of the tadpoles of this species which had only just emerged from the egg stage. At this stage they come to the surface and rest for a time before commencing an active existence. I collected a large quantity and brought them home to study the development and the following is the result:—

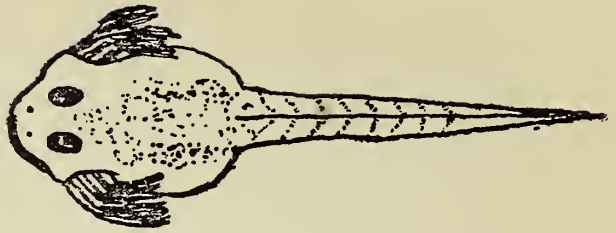
9-6-29. Length of tadpole 10 mm. branchial aperture open on either side of the body with the external gills protruding. Three sets on either side. Examination of the mouth showed the beak was but feebly horny, and as far as I could see with a high powered dissecting microscope, no rows of horny teeth were present. At this stage the tadpoles kept to the surface of the water and submerged only when disturbed, only to return to the surface almost immediately. It appears to me that the 'suckers' in some way help to keep them at the surface. The tadpoles were not at all active.

10-6-29. In the same condition as the previous day, but a little more active; swimming about.

12-6-29. Length of tadpole 13 mm. The branchial pores on either side of the body were closed and the external gills had been absorbed. A single branchial pore open on the left side of the body. The beak, much more horny than on the previous day; three rows of horny teeth visible; one above and two below. The upper row extending in a curve across the mouth, lower rows short as shown in Plate IV, Fig. 7. The lips considerably enlarged. The



1



2



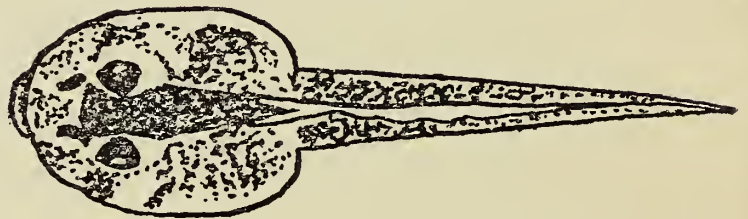
3



4



6



5



7



8

Del. C. McCann.

Rana tigrina, Daud. 1. Tadpole 10-6-29, $\times 5$, lateral view. 2. Dorsal view of figure 1. 3. Ventral view of figure $\times 9$ to show suckers and external gills. 4. Beak of tadpole figured in figure 1. 5. Tadpole on 12-6-29, $\times 5$. 6. Dorsal view of figure 5. 7. Arrangement of beak and teeth on 12-6-29. 8. Arrangement of beak and teeth on 13-6-29.

- 'suckers' had completely disappeared. Much more active and moving about freely, though generally near the surface; continually opening and closing the mouth.
- 13-6-29. Length of tadpole 21 mm. More pigment appeared all over the body, particularly at the extremity of the tail membrane. (a very characteristic feature of the tadpoles of *R. tigrina*.) The beak now almost black. Additional rows of horny teeth developed Plate IV, Fig. 8. A circular horny plate appeared on the palate.
- 16-6-29. Length of tadpole 28 mm. The tail more acuminate and its extremity more deeply pigmented. The hind limbs appeared as two minute conical protuberances at the base of the tail. On the tip of these conical structures there were four very minute buds representing the digits on each. Further pigment appeared and the teeth became more horny black.
- 18-6-29. Length of tadpole 31 mm. The pigmentation greatly increased. The conical hind limbs developed further.
- 30-6-29. Length of tadpole 39.5 mm. Hind legs 5.5 mm. Toes distinguishable. Another tadpole measured on the same day was 45 mm. long. The hind legs fully developed, complete with webs between the toes. Fore legs fully developed and distinctly visible through the skin of the branchial chamber.
- 4-7-29. Metamorphosis completed. Tail partially absorbed. Beak and horny teeth shed. No teeth in the mouth.
- 15-7-29. By this time not all of the tadpoles had completed their development.
- 8-8-29. A young frog that had been kept alive and fed measured 22 mm. long and was fully pigmented. The teeth were feebly developed.

Another set:—

- 15-6-31. The spawn was laid after some very heavy showers of rain, when it was collected.
- 16-6-31. The size of the larvæ before they left the slimy envelope varied from 5-7 mm. In colour they were brownish and the surface of the body appeared to be minutely granular. The external gills were in different degrees of development, from conical protuberances to feather-like structures, according to the age of the larva. The suckers were not recognisable in very small larvæ, but were distinct in the larvæ measuring 7 mm. The mouth was represented by only an invagination of the skin at that region. Eyes were not distinguishable. The position of the nostrils was distinct.
- 18-6-31. Length of tadpole 12.5 mm. External gills completely lost. The brownish pigment of the larval stage disappeared and quite a different type of pigment appeared, in the deeper layers of the skin as blackish dots. The tail membrane which in the larval stage was opaque now became quite transparent. The pigmented region of the tail was marked with reddish-brown spots. The lips were well developed. Beaks and rows of teeth distinctly horny.
- 20-6-31. Length of tadpole 12.5 mm. In much the same condition as on the 18th. Pigment in the deeper layers more intensified and another type of pigment appeared on the surface like minute black streaks on the upper side of the body, and on the tail.
- 23-6-31. Length of tadpole 25.5 mm. (This tadpole with two others developed exceedingly fast and were the largest of the group.) Tail became more acuminate. Pigment increased. Beak and teeth well developed. No palatine plate.
- 26-6-31. Length of tadpole 17 mm. Hind legs began to appear. Terminal portion of tail very deeply pigmented, almost black.
- 7-7-31. Length of tadpole 32 mm.
- 14-7-31. Two tadpoles were removed. Length: (a) With hind legs partially developed 37 mm. Hind legs 5.5 mm. (b) With hind legs almost fully developed 39 mm. Hind legs 16 mm.
- 15-7-31. One of the tadpoles with all the four legs developed, but which

had not left the water measured 39 mm. Hind legs 23.5 mm. Horny teeth and beak shed. Lips absorbed.

On the same day a young frog which emerged from the water and which had completely lost its tail measured 18 mm. from vent to snout. Hind legs 24 mm.

8-8-31. On this day the balance of the tadpoles were bottled. Up to this time not all of them had completed their development. Many of them were still small and legless.

These records however incomplete they may be help to indicate the approximate time occupied by these frogs to complete their metamorphosis—29 days in the first observation and 23 in the second. They also show how irregularly the tadpoles develop, though this was perhaps the more accentuated by the artificial conditions under which development took place. It is obvious from the above that all frogs born during one season complete their metamorphosis well before the end of the rain and no aestivation takes place during the tadpole stage.

It is interesting to note that the tadpoles of this frog, like those of *R. cyanophlictis*, also feed on mosquito larvæ.

RANA LIMNOCHARIS, Wiegman.

The Streaked Frog.

A very common species abounding in the neighbourhood of tanks and streams, when these are perennial. During the dry season these little animals either collect under stones etc. in damp places during the day, particularly near a spring and come out when the sun has gone down, or they aestivate. During the monsoon they wander far and wide in the grass and may be found both day and night.

At the beginning of the rains or a little before, large numbers collect on the banks of perennial streams and tanks to deposit their spawn. At this time the males, which appear to predominate, keep up an incessant croaking. The croaking commences as soon as it is dusk and only ceases with daybreak, but on dull days during the early monsoon they may be heard throughout the day. The vocal sacs, one on either side of the gape are blackish. The voice is fairly powerful and much resembles the clatter of castanettes in the distance. To produce the sound the abdomen is first inflated, and in deflation fills the vocal sacs with air, in this way the abdomen and the vocal sacs are alternately inflated and deflated.

When alarmed the frogs take to the water and submerge, but only for a short while, very soon they rise to the surface and swim ashore again, seeking shelter in the vegetation. They are extremely active little creatures. Annandale (*l.c.*) correctly observes that this species is incapable of 'skipping' over the surface of water as is the characteristic practice with *R. cyanophlictis*—nor does it float on water like *cyanophlictis*, but rests with the legs hanging down below the surface.

So far I have not come across the spawn nor the tadpoles of this species though I have repeatedly seen them in amplexus at the commencement of the rains.

In common with many other frogs, I have observed large numbers together, aestivating in crevices of rocks and under large stones.

A very common feature of this frog, is the stripe or streak (from the presence of which I have suggested the English name) down the centre of the back. In my opinion this character cannot be relied on as it may vary in width and colour and may even be absent, in the same locality.

RANA RUFESCENS, Boulenger.

The Rufescent Frog.

Of this species I secured several immature specimens. They were found on bare water-washed rocks on the hillsides adjoining the Kune Kathkari Settlement, Khandala, Western Ghats.

The general colour is a deep brown almost approaching the blackish colour of the rocks. The general markings of freshly caught specimens were very indistinct. Certain tracts of colour are well defined. The upper portion of the arms (*humerus*), the upper surface of the thighs (*femur*) and just behind the head the colouring is a bright crimson or brick-red. In some of the specimens the colour of the arms and behind the head has a tendency of forming a continuous patch. This colouring disappears some time after the specimens were put into preservative. Observed under natural conditions these patches of colour appear to break up the form of the frog and give it the semblance of algæ adhering to the rock.

The Rufescent Frog is a squat little animal with little to distinguish it at a glance from the immature form of the next species, *R. breviceps*.

Dr. Smith writing to me about this species says that it is the first time that it has been found so far north. Up to this time it has only been recorded from Malabar.

RANA BREVICEPS, Schneid.

The Burrowing Frog.

A clumsy looking species, nocturnal even during the rains. After dark I found this frog quite common on the roads at Panchgani. Should it chance to fall into water and not be able to get out, it appears very uncomfortable, but nevertheless, it readily submerges if alarmed, but soon reappears on the surface. Specimens kept in captivity fed readily on insects.

This species is in the habit of digging itself in during the day. At Khandala, I found one which had dug itself in almost a foot below the surface.

RANA LEITHII, Boulenger.

Leith's Frog.

With its digital discs and slender build this species much resembles one of the tree-frogs.

Leith's Frog was not uncommon in the short grass and in the

ditches on the hillsides adjoining the Kune Kathkari Settlement at Khandala. In September of 1931, I secured a few of these frogs. To all appearances this frog appears to be diurnal at least during the rains. It was frequently seen hopping about in the grass.

In colour it is a pale brown, almost sandy, with darker markings. The limbs, particularly the hind legs, are transversely banded with dark brown.

In his letter, Dr. Smith stated that up till the time of my securing the specimens sent to him for identification, this species was only known from a single individual in the collections of the British Museum—the type—which was secured from Matheran.

RANA MALABARICA, Dum. & Bibi.

The Fungoid Frog.

This species is fairly common in the Island of Salsette and at the north end of Bombay Island. It generally inhabits forested areas, but may be seen occasionally in open country. It is terrestrial and semi-arboreal in habit, and is frequently found perched high up on the bark of trees and on the leaves of bushes. In all probability it is a diurnal species as I have often come across it during the day, but have so far not found it about at night.

The colouring of the frog is strikingly characteristic. The dorsal surface, including the head, is brick- or orange-red (sometimes crimson and sometimes in specimens in poor condition, yellowish). A sharp narrow white or yellowish line commencing at the snout, passing from behind the eye to the vent divides the red dorsal surface from a broad greyish black band along the flanks. The dark lateral band passes into mottlings on the under-surface of the frog. Both the hind and fore limbs are transversely, but irregularly barred. The eyes are tinged with bright red and gold. On the whole it is a very handsome creature. When seated on a tree trunk, the colouring on its back gives it the appearance of a red bark fungus as the outlines of its dark flanks are lost against the bark, and its limbs gathered well up under its body are lost to view.

This frog is not at all shy. It sits close, and will allow one to approach quite near and may even allow one to touch it. So like a fungus indeed is the appearance of this frog, so apparent is its reluctance to get away that I have no doubt that the species relies almost entirely on its colouring for protection. I do not mean that the animal is aware of its protecting colours, but the habit of the creature combined with its peculiar colour must enable it to escape detection by such animals that would prey on it.

The extremities of the digits are sometimes swollen and adhesive, though they are not so well developed nor have they the same adhesive power as in the case of *Rhacophorus maculatus*—the Chunam Frog.

When handled the call of this frog is not unlike the mew of a kitten plus a sort of high pitched 'kut kut' repeated several times. I am not familiar with the call at the time of breeding.



The Fungoid Frog (*Rana malabarica*, Dum. & Bibr.) showing dorsal and lateral aspect.

Photos by S. A. Ali.



A spawn mass of the Giant Tree-Frog (*Rh. maximus*, Gunth.)
(A match box shows it's comparative size.)



Rhacophorus maximus, Gunth. Another mass of eggs laid in the tangle of twigs covering the water.

Photos by C. McCann.